Dissolved and Bubble Gas Concentrations in Sandy Surficial Sediments of the West Florida Sand Sheet

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LONG-TERM GOALS

We hope to further our understanding of biogeochemical and physical processes controlling the production, transport and consumption of biogenic gasses in diverse sedimentary environments and sediment types. In sandy sediments, our focus is on oxygen produced through benthic primary production by algae living in the surface sediments.

OBJECTIVES

In this phase of the project our primary objective was to develop an advection-diffusion-reaction model for oxygen in surface sediments colonized by phototrophic organisms. The model could then be used to explore the conditions under which benthic photosynthesis leads to the production of oxygen bubbles due to supersaturation. The original motivation for this was concern over site location for the October 1999 experiments of the High Frequency Sound Interaction in Ocean Sediments DRI (Directed Research Initiative). Sites without any gas phase in the sediments were sought. In sediments of the selected sites there was no concern over methane because the sediments were sandy and low in organic matter. However, at the ~60' depth of these sites there was significant benthic productivity possible and we sought a way to determine if oxygen supersaturation could be achieved at this, or any other future study location, given the levels of productivity possible. The model gives us an easy way to explore this possibility.

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APPROACH

During the DRI in 1999 oxygen profiles were characterized aboard ship via oxygen microelectrode inserted with a vernier-type micromanipulator. Profiles in a given core were followed throughout the day while it incubated on deck under several layers of screening to mimic the light on the bottom. Since we were working at atmospheric pressure, instead of *in situ*, we could not suppress the formation of oxygen bubbles at the sediment surface. Bubble formation *in situ* would require much higher concentrations, which would have to build up against very steep diffusive gradients. This shipboard work demonstrated that there was an active phototrophic community at the sites to be studied acoustically.

In the new work we have developed a model to simulate the processes affecting oxygen concentrations. This is similar to a methane model published earlier (Martens et al. 1998, Albert et al. 1998). In the oxygen model, the inputs include the water depth (which affects saturation), temperature (which affects saturation and diffusivity), current speed 1 m above the bottom (which affects the thickness of the diffusive boundary layer), and the magnitude and shape of the oxygen production and consumption profiles. We don't know all of these parameters, but can make reasonable assumptions based on published literature. The model output is oxygen concentration vs. depth. Where the concentrations exceed *in situ* saturation we would predict an oxygen gas phase in the surface sediments.

WORK COMPLETED

The oxygen model is finished and running. We will run it with the input parameters varied over realistic ranges to establish limits on the conditions under which an oxygen gas phase could be expected in surface sediments. This may be of future use in site location for acoustic experimentation.

RESULTS

An example of a model run is shown in Figure 1. In this case the input parameters were varied to try to achieve a good fit to an oxygen profile measured by microelectrode. The overall oxygen production rates used are within ranges seen in sandy shelf environments (Jahnke et al., 2000, Cahoon and Cooke, 1992). The attenuation of photosynthesis with depth in the sediment used here is consistent with results reported by Kuhl and Jorgensen (1994) who showed that most activity occurs within the upper 2.5 mm of the sediment due to the rapid attenuation of photosynthetically active radiation (PAR) with depth.

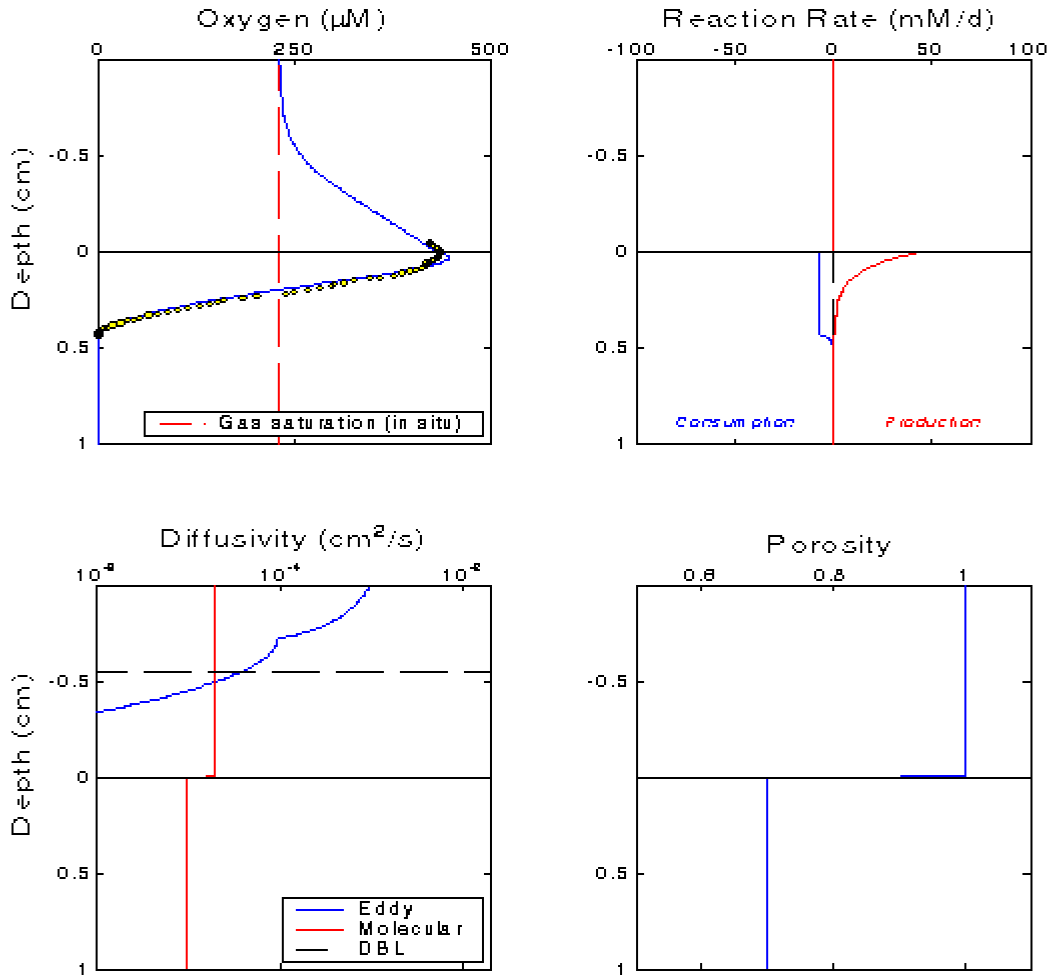

Figure 1. Example of a model run to achieve a best-fit to oxygen data obtained by microelectrode profiling in sandy sediments off Panama City Beach, Florida. The dashed line in the upper left panel indicates oxygen saturation concentration under the conditions input (zero depth and 20°C). The other panels depict how the other input parameters vary with depth. The horizontal dashed line indicates the top of the diffusive boundary layer. Diffusivity is dependent on the input temperature and the current speed 1 m above the bottom.

IMPACT/APPLICATIONS

Once the modeling is complete it should be possible to place generalized constraints on the occurrence of gaseous oxygen at prospective study sites based on water depth and clarity (due to its effect on PAR supplied to benthic algae).

TRANSITIONS

When finished, these model results may help guide future site selection for acoustic experimentation in shallow waters where presence of a gas phase is of concern.

RELATED PROJECTS

The other projects of the High Frequency Sound Interaction in Ocean Sediments DRI are related in that data interpretation of many of the acoustic experiments is dependent on knowledge of whether or not gas bubbles are present in the sediments.

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